GEOMORPHOMETRIC APPLICATION FOR WATER RESOURCE MANAGEMENT IN RANCHI DISTRICT

PROPOSED SYNOPSIS FOR Ph.D. REGISTRATION

DEPARTMENT OF GEOGRAPHY, RANCHI UNIVERSITY, RANCHI

(SOCIAL SCIENCE DEPARTMENT)

2023

NAME OF THE SUPERVISOR

DR. JITENDRA SHUKLA

ASSISTANT PROFESSOR

UNIVERSITY DEPARTMENT OF GEOGRAPHY

RANCHI UNIVERSITY, RANCHI

NAME OF THE CANDIDATE

SUSHILA KUJUR

* A Brief Introduction of the research topic

Introduction:

Water resource management in Ranchi district regions is essential for ensuring sustainable water resources and supporting various ecological systems and human activities. These areas pose unique challenges for water management due to factors such as limited rainfall, high evaporation rates are limited natural storage options like lakes and rivers.

Geomorphometry which refers to the quantitative analysis of land surface characteristics can have various applications in water resource management. Morphometric descriptors represent relatively simple approaches to describe basin processes and do compare basin characteristics (Mesa 2006) and an enhanced understanding of the geomorphic history of a drainage basin (Strahler 1964). Drainage basin morphometric parameters can be used to describe the basin characteristics. They are basin size (stream order, stream length, stream number and basin area), basin shape factors (circulatory ratio, elongation ratio, form factor and compaction ratio), basin perimeter, bifurcation ratios, drainage density, stream frequency and drainage intensity. The basin morphometric characteristic of the various basins have been studied by many scientists using conventional (Horton, 1945; Smith, 1950; Strahler, 1957) and remote sensing and GIS methods (Krishnamurthy and Srinivas, 1995; Srivastava and Mitra, 1995; Agarwal , 1998; Biswas et al., 1999; Narendra and Nageswara Rao, 2006, Kumar, Mallick et, al., 2012, Kumar, Parveen and Mallick, 2012; Parveen and Kumar, 2012)

Prior to 1945 such studies where concentrated on qualitative and deduction aspects. A new era of quantitative analysis was initiated by Horton in 1945 who first applied involves evaluation of stream properties, analysis of various drainage parameters namely ordering of the various streams and measurement of area of basin, perimeter of basin, length of drainage channels, drainage density (Dd), drainage frequency bifurcation ratio (Rb), texture ratio (T), circulatory ratio (Rc), basin relief (Bn) and length of overland flow (Lg) to predict the approximate behaviour of the watersheds during periods of heavy rainfall [3,4], the present study describe the capabilities of Geomorphometric study to the drainage characterstics of Ranchi river basin in order to understand the water resource management.

Overall, geomorphometric applications in water resource management provide valuable insights into watershed dynamics, hydrological processes and land surface characteristics. This information supports effective decision making. Sustainable water resource planning and the protection of water related ecosystems.

*State-of-the-art:

1. Jayesh Mukherjee, Priyank Pravin Patel (2022) has explored combine classical and modern morphometric methods to examine the terrain characteristics of the Kharkai River Basin chosen for its diversity of landforms and human activities. While traditional methods have been based on eliciting terrain information from topographical maps, they use a higher resolution Digital elevation Model (DEM) to extract such attributes. The stream network was derived using flow-routing and flow accumulation algorithms and a net of 1 km x 1 km grids was overlain on the DEM to compute various morphometric.

2. Rafique Ahmad Hajam, Aadil Hamid, S.bhat (2013), has explore morphometric analysis has been carried out using Geographical Information System (GIS) techniques to assess drainage Basin and an attempt has been made to identify the ground water potential zones through geomorphometric spaces. The development of stream segments in the basin area is affected by rainfall, groundwater discharge and snow melt over. The analysis has revealed that the total number and length of stream segments is maximum in first order streams and decreases as the stream order increases parameters show that it has low discharge of runoff, generally permeable subsoil condition, moderate to high infiltration capacity and good groundwater resources and a flatter peak of flow of longer duration that is easier to manage that of the circular Basins.

3. Reshma Parveen, Uday Kumar, Vivek Kumar Singh. (2012), they studied and reveals that GIS and remote sensing can be very useful in evaluation of various morphometric parameters and its influence on landforms. Interpretation of satellite images can help delineat lithological and geomorphic Units. GIS facilitates analysis of various morphometric parameters and act as an effective tool in establishing relationship between drainage morphometry and properties of landforms. The study also reveals that DEM can useful in studying the topography within GIS environment

Geomorphological study of an area is the systematic study of a present-day landforms, related to their origin, nature, development, geologic changes recorded by the surface features and their relationship to other underlying structures. Therefore, it has become an integral part of groundwater study an area. Some morphometric elements (measurement of landforms) provide valuable information for good water condition.

4. P. Kumar, v Joshi(2015) they stated the investigation of geohydrological features of drainage basin is necessary for planning and implementation of various watershed development programmes. The visual interpretation techniques coupled with morphometric analysis used in the present study to evaluate the geomorphic process of upper watershed of river Subarnarekha in the state of Jharkhand, India. They explored that the upper watershed of River Subarnarekha is of eighth order with dendritic drainage pattern, the study also concludes that the geomorphic development of drainage basin is highly affected by slope and elevation, whereas is affected by rainfall pattern and infiltration.

5. Nageswara K Rao, Swarna P Latha, Arun Kumar, Hari M. Krishna (2010), they explored GIS and image processing techniques have been adopted for the identification of morphological features and analyzing their properties of the Lower Gotsani River Basin (LGRB) area in Andhra Pradesh state, India. The basin was determined and computed. The area is occupied by 96% Khondalite group of rocks. It is 7^{th} order drainage basin and drainage pattern mainly in sub-dendritic to dendritic type. It is observed that the drainage density value is low which indicates the basin is highly subsoil and thick Vegetative cover. The circularity ratio value reveals that the basin is strongly elongated and highly permeable homogenous geologic materials. This study would help the local people to utilize the resources for sustainable development of the basin area.

6. Praveen Kumar Rai, Rajeev Singh Chandel, Varun Narayan Mishra, Prafull Singh 2018, they – explored. The effectiveness and advantage of remote sensing and GIS-based analysis for quantitative and qualitative assessment of flood plain region of lower Kosi River basin based on morphometric analysis .This article gives the idea of using the ASTER DEM to extract the vital hydrological parameters of lower Kosi River Basin in ARC GIS Software. Morphometric parameters e.g., stream order,

stream length, bifurcation ratio, drainage density, drainage frequency, drainage texture, form factor, circularity ratio, elongation ratio etc. Most of the morphometric parameters such as bifurcation ratio, drainage density, drainage frequency, drainage texture concluded basin has good prospect for water management program for various purposes and also generated data base that can provide scientific information for site selection of flood management activities in the basin.

This some literature review will help in my research for further study on my topic – Geomorphometric application for Water Resource Management in Ranchi district.

*Study Area:

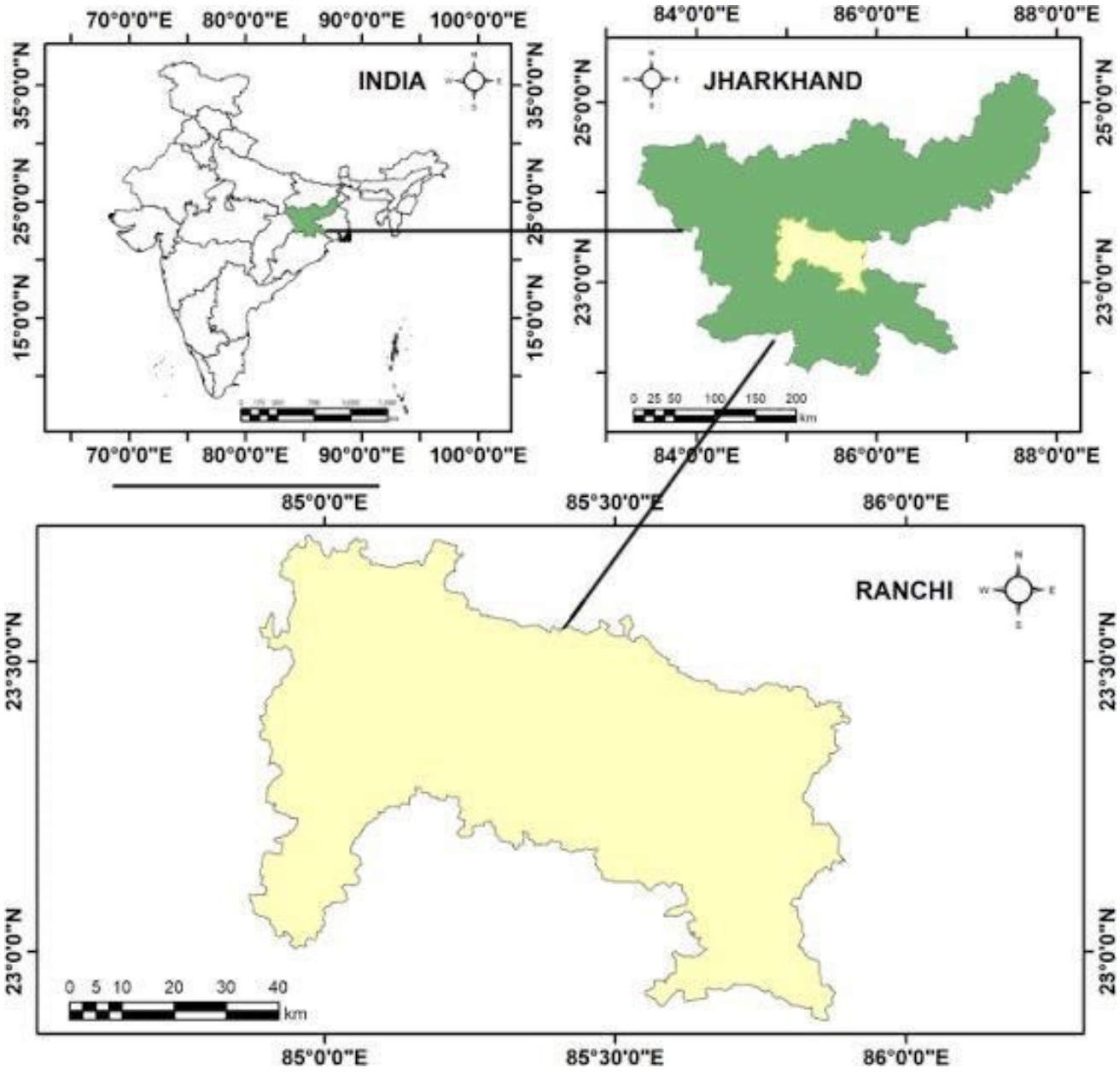
Ranchi district with an area of 5,097 sq.km bounded by latitude 23.35°N and longitude 85·33°E. The total area covered by the Ranchi municipal area 175.12 sq. km. and the average elevation of the city is 651m (2140 feet) above the sea level. The Ranchi city is located in southern part of the Chotanagpur plateau which forms the eastern edge of the Deccan Plateau.

The plateau is characterized by its undulating topography and its home to several rivers streams and reserve reservoir that contribute to the reasons water supply water resource management in the Ranchi plateau area involve the planning development and conservation of water resources industry and the environment

Ranchi district is located in the Indian state of Jharkhand and is known for its rich natural beauty and divers geomorphological features. The district lies in the chotanagpur plateau region, which is characterised by rugged terrain, hills, valleys, rivers and the plateau.

An apart of the largest Deccan plateau. It is composed of sedimentary rocks, including sandstone, shale and limestones.

LOCATION MAP OF RANCHI DISTRICT



*Problems to be Investigated:

1. **Watershed Delineation:-** Determine the boundaries and characteristics of the different watersheds within Ranchi district .Investigate the size, shape, slope and drainage patterns of these watersheds to understood their hydrological behaviour and water resource potential.

2. **Stream Network Analysis**: - study the network of streams and rivers in Ranchi district. Analyse parameters such as stream order, length, density and connectivity to assess the overall stream network structure and its influence on water availability and flow dynamics.

3. **Drainage Density and Basin Shape: -**Calculate the drainage density and basin shape factors to evaluate the compactness and efficiency of water drainage in the region. Assess how these factors affect surface runoff, groundwater recharge and flood potential.

4. **watershed Topography: -** Investigate the topographic characteristic of watershed including elevation, slope, aspects and relief. Analyse how these factors influence water movement. Soil erosion and distribution of water resources within Ranchi district.

5**. Land use/Land Cover Analysis**: - Conduct a comprehensive analysis of land use/ land cover pattern in Ranchi district. Determine the extent of agricultural land, forests urban areas in other land uses to understand their impact on water resources, including surface runoff, infiltration rates and water quality.

Apart from these other issues like - Reservoir sitting and Design, Groundwater Potential, Flood Vulnerability Mapping, Erosion and Sedimentation Analysis and Hydrological Modelling had also helping to investigate.

*Objectives of the Investigation and Motivation:

1. To study and analyse the morphometry and its application, utilization and management of water resources.

2. To limelight the problems of ever degrading water resources and application of morphometric attributes for the management of water resources.

3. To study the climatic conditions experiencing in the district and its effect on ground water occurrences and agriculture productivity.

4. To carry out morphometric analysis of the area river basin by determining various parameters relating to surface and ground water occurrences.

*Research Hypothesis:

1. Application of morphometric attributes are very significant in the judicious management of water resources.

2. Ever increasing population pressure and growth depleting the water resources.

3.Proper and judicious management is essential for water resource management.

*Research design and Methodology:

Morphometric analysis of the river basin of Ranchi district was carried out, using SOI topographical maps 73A/14, 73A/15, 73A/16, 73E/2, 73E/4, 73E/6, 73E/7, 73E/8, 73E/10, 73E/11, 73E/12, 73E/15, 73E/16, 73F/9 and 73F/13 on a 1:50,000 scale. The analysis includes the aspects such as stream order, stream length, streamlength ratio,elongation ratio, drainage density, and bifurcation ratio etc.

1. Field investigation and sampling- Using GIS and remote sensing data, topographic aspect and slope directions maps will be constructed for the drainage network in the study area showing the water divide and the catchment area along with the morphology pattern, streams, ephemeral rivers, dry creeks, erosion gullies undulations, tributaries to the main streams, and basins of the well-developed.

2. Surface Hydrology (Basin Analysis)

Basin Geology and Geomorphology -

The portion of the precipitation which infiltrate may add to the moisture content of the soil or may become ground water. The most influential factors in determining the steadiness or variability of flow is the source of supply. To study the basin geomorphology, basin is described by introducing the concept of stream orders. The drainage basin features of hydrologic importance are elevation, stream length, basin perimeter drainage area.

Morphometric Analysis Using Arch-Hydro GIS Technology and STRM Analysis system-

The raster GIS procedures were utilized and arch-Hydro, state-of-the-art GIS technology for watershed sciences, was used to delineate the drainage basins and measurements and parameters are useful in a wide range of application, including landform characterization, hydrological modelling. Soil erosion assessment, land use and geomorphometric analysis techniques are typically implemented using GIS (Geographic Information System) software and algorithms that operate on digital elevation data.

***Tentative chapterisation :**

Introduction

Chapter 1: Geomorphic outline of the district

Chapter 2: Morphometric analysis as Linear aspect

Chapter 3: Morphometric attributes as Areal aspect

Chapter 4: Morphometric analysis as Relief aspect

Chapter 5: Hydrological characterizations of the Basin

Chapter 6: Problems of water Resources depletion in Ranchi

Chapter 7: Application of Morphometric attributes for water Resource management in Ranchi district

Conclusion

Bibliography

Appendix

LOG FRAME WORK:

	Parameters	Formulae	Description	Reference
1	Stream Order (Nu)	Hierarchical Rank	The channel segment of the drainage basin has been ranked in hierarchical order	Strahler (1964)
2	Stream Length (Lu)	$Lu = \sum Nu$	Rb was computed as the ratio between the number of streams in the next higher order (Nu+1)	Horton (1945)
3	Bifurcation Ratio (Rb)	Rb=Nu/(Nu + 1)	Rb was computed as the ratio between the number of streams in the next higher order (Nu + 1)	Schumn (1956)
4	Drainage Density (D)	D = L/A	D was measured as length of stream(L)channel per unit area(A)of drainage basin	Horton (1945)
5	Stream frequency(fs)	Fs = N/A	Fs was computed as the ratio between the total number of streams and area of the basin	Horton (1945)
6	Texture Ratio (T)	T = D x Fu	T was estimated as the ratio between the total no of streams of all order and perimeter of the basin	Horton (1945)
7	Circulatory Ratio (Rc)	Rc = $4\pi A / P^2$	Rc was computed as the ratio between the basin area and total stream involved in the ratio	Strahler (1964)
8	Average overland flow (Lo)	Lo = 1/2(D)	Lo is expressed as equals to half of reciprocal twice of drainage density	Horton (1945)
9	Constant of Channel Maintenance (C)	C=1/D	C is expressed as the reciprocal as the product of bifurcation ratio and total streams involved in the ratio	Horton (1945)
10	Weighted mean ratio (Rbwm)	Mean of (Rb x total streams involved in the ratio)	Rbwm is expressed as the ratio between the basin area and square of the basin length	Strahler (1964)
11	Form Factor (Ri)	$Ri = A/(Lb)^2$	Ri was computed as the ratio between the basin area and total stream involved in the ratio	Horton (1945)
12	Sinuosity Index (Si)	Si= Channel length/down valley distance	Sinuosity has been defined as the ratio of channel length to down valley distance	Mueller (1968)

*Source of Data and tools to be used in collection of data

1. Digital Elevation Models (DEMS) –

DEMS provide elevation information of the terrain and are essential for deriving geomorphometric parameters. DEMS can be obtained from various sources, including national mapping agencies, satellite imagery providers or open data platforms like the Shuttle Radar Topography Mission (SRTM) or Advanced Spaceborne.

2.Satellite Imagery –

High resolution satellite imagery can be used to extract landcover information, identify water bodies and monitor changes in surface water resources over time Data from satellites such as land-sat, Sentinal-2 or Commercial provides like Digital Globe can be used for this purpose.

3.Ground based surveys –

Field surveys can provide valuable information on the ground truthing of water resources. These surveys may involve measuring streamflow, water quality parameters, groundwater levels, and identifying specific hydrological.

4.Hydrological Data -

Historical hydrological data such as rainfall, river discharge, groundwater levels and water availability records can be obtained from local hydrological department, research institutions, or government agencies responsible for water resource management.

5.Soil Data-

Soil information, including soil type, permeability, infiltration rate and water-holding capacity, is crucial for understanding water movement through the landscape. Soil data can be obtained for soil surveys, local agricultural or land management departments.

5. Geospatial Databases -

Regional or national geospatial databases maintained by government agencies often contain relevant information for water resource management. These databases may

include infrastructure data (e.g. dams, reservoirs, irrigation channels) administrative boundaries and other spatial layers that can aid in the analysis.

*Analysis of Data

1. Basin Delineation: – Using the DEM, we can delineate the drainage basin Boundaries within Ranchi district. This helps in identifying the contributing area and the extent of the water catchment.

2. Stream order classification: - Stream ordering classifies the stream based on their hierarchical position with the drainage network. It provides insights into the network structure, flow paths and the potential for flood generation.

3. Calculation of Morphometric Parameters:- Several morphometric Parameters can be derived from the digital elevation data and stream network. These parameters can be derived from the digital elevation data and stream network. These parameters include basin area, basin perimeter, length of streams, stream density, drainage density, slope, shape factor etc. They help in characterizing the basin's shape, size and relief, which influence water availability and flood potential.

4. Hypsometric Analysis:- Hypsometric Analysis involves studying the relationship between the elevation of the basin and its area. This analysis provides insights into the stage of landscape evaluation, erosion levels, and potential for water storage.

*Significance of the Study

Applying morphometric analysis to water resource management can aid in optimizing water availability, mitigation floods and erosion, identifying suitable sites for water storage, and facilitating sustainable water resource planning. It allows a better understanding of the hydrological characteristics of the region, enabling effective management and conservation of water resources for the benefit of the local population, agriculture, and other sectors reliant on water.

*Its relevance to the present day problem and needs to the society:-

Its relevance and benefits to address present day problems and societal needs. Here are some key points-

1. Drainage network analysis- By analyzing the length, density and frequency of streams and rivers, It becomes possible to assess the availability and distribution of water resources, identify potential areas for water storage and plan effective flood management strategies.

2. Watershed Management- By studying the shape and size of the watershed, it becomes possible to identify areas susceptible to erosion, determine the flow accumulation, patterns and prioritize. The implementation of soil and water conservation measures. This information can help in sustainable land use planning and management practices, which are vital for preserving water resources and preventing soil degradation.

3. Hydrological Modelling- By quantifying the Basin characteristics, such as slope, aspect and land cover it becomes possible to stimulate the water cycle estimate water availability, and predict the impacts of land use changes or climate variability on water resources. This information can guide decision-making related to water allocation, infrastructure development and drought or flood management strategies.

4. Water resource Planning – Morphometric analysis provides valuable inputs for water resource planning and development by understanding the hydrological characteristics of the region, such as the water yield, sedimentation rates, and ground water recharge potential. It becomes possible to assess the sustainable water availability, design appropriate water supply schemes and promote efficient water use practices. This information can guide policy makers, urban planners and water supply agencies in making informed decisions and formulating long-term water management strategies.

*Contribution to the existing Knowledge:

1. Morphometric analysis can help identify and classify the drainage patterns within Ranchi District, such as dendritic, trellis or radial patterns. This information can provide insights into the geological and structural characteristics of the area, enabling better understanding of the surface water flow and drainage network connectivity.

2. Morphometry can aid in delineating the watershed boundaries within Ranchi district. By demarcating the catchment areas and estimating their characteristics (e.g. size, shape, relief), water resource managers can assess the hydrological response of different watershed to rainfall events. This knowledge is essential for designing effective water management strategies and flood control measures.

3. Morphometric Parameters, such as stream order, stream length, bifurcation ratio, and drainage density can be computed to analyze the stream network within Ranchi district. These parameters provide information about the hierarchical structure of the drainage systems, its efficiency in transporting water, and the potential for erosion and sedimentation such analysis assists in identifying critical areas that requires attention in terms of erosion control and sediment management.

4. Hydrological Modelling -By integrating Morphometric Parameters with rainfall data, soil properties and land use information, hydrological models can help predict water availability, flood potentials and ground water recharge rates. These predictions support decision-making in water allocation, research operation and flood risk management.

5. Morphometry can also contribute to assessing the environmental impacts of water resource management activities in Ranchi district. By comparing Morphometric characteristics, such as changes in stream lengths, slopes or basin shapes, it is possible to evaluate the effectiveness of various interventions, such as dams, reservoirs or water diversions on the hydrological regime and ecological balance.

*Future work:

A potential future work in Geomorphometric applications for water resource management in Ranchi district could involve advanced modelling techniques to predict and manage water availability, flood risks, and erosion patterns. Integrating remote sensing data, GIS, and hydrological models could provide valuable insights for sustainable water management strategies in the region.

*Related Reference

1. Jayesh Mukherjee & Priyank Pravin Patel (2022) Landscape characterization using Geomorphic-metric Parameters for a small sub Humid River Basin of the Chotanagpur Plateau, Eastern India. Drainage Basic Dynamics.
2. Rafiq Ahmad Hajam, Aadil Hamid, S Bhal. “Application of morphometric analysis for geo-hydrological studies using geospatial technology –“ a case study of Vishav Drainage Basin”,Hydrology current Research 4 (3), 1-12, 2013.
3. Geomorphometric Characterization of upper South Koel Basin, Jharkhand: A remote sensing & GIS Approach.
4. “Characterization of hydrogeological behavior of the upper watershed of River Subarnarekha through morphometric analysis using Remote sensing and GIS.”- P. Kumar, V. Joshi. 2015, Environmental Science
5. “Drainage Morphometric analysis and water resource management of Hindon river basin using earth observation data sets.” Arnab Saha, Prafull Singh (2017).
6. Nageswara K Rao, Swarna Platha, Arun P Kumar, Hari M Krishna – “Morphometric analysis of Gostani River basin in Andhra Pradesh state, India using spatial information technology.
7. “Hydrological inference through morphometric analysis of lower Kosi river Basin of India for water resource management based on remote sensing data”, Praveen Kumar Rai, Rajeev Singh Chandel, Varun Narayan Mishra, Prafull singh- Applied water science 8, 1-16, 2018.
8. A. N. Strahler, “Quantitative Analysis of watershed Geomorphology”, - America Geophysical Union, Vol 38, No. 6, 1957, PP.
9. Savindra Singh. “Morphometry of drainage basins – Geomorphology”,-P.P.-353-384